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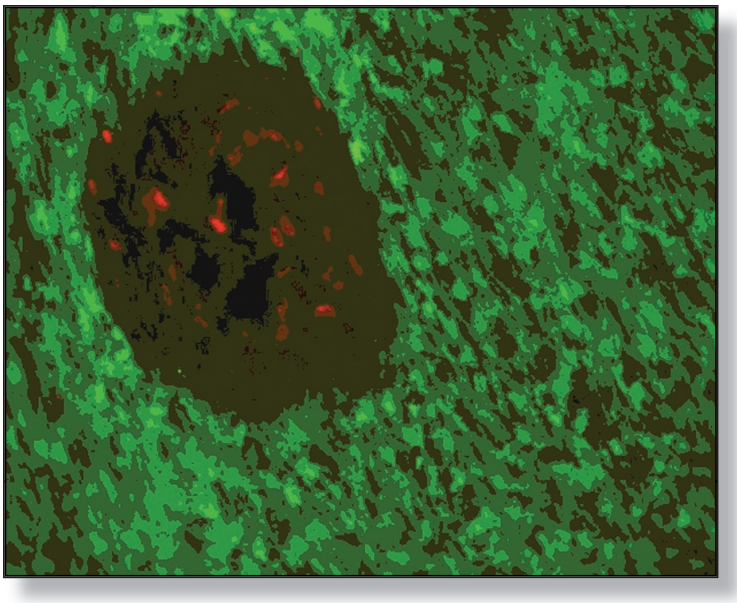
Success Story

NEW CELL CULTURES KEY TO EXPERIMENTAL VERIFICATION OF LASER EYE DAMAGE



Scientists from the Human Effectiveness Directorate demonstrated the capability of using artificially pigmented ocular cells, cultured *in vitro,* to assess eye damage resulting from both acute and chronic laser exposure. This cell culture, when coupled with novel biomolecular assays, can assess damage mechanisms and thresholds for exposure to lasers without having to conduct live animal testing.

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Accomplishment

The directorate's laser bioeffects team, headed by Dr. Ben Rockwell and Dr. Michael Denton of Northrop Grumman, developed a novel *in vitro* assessment for determining retinal damage endpoints. Studies of laser bioeffects performed *in vivo*, especially in the eye, have led standard-setting bodies to treat laser pulses arriving at a rate faster than 20 kHz (50 kHz for near infrared) as equivalent to a continuous wave (CW) exposure.

Using a newly developed artificially pigmented cell culture system, the laser bioeffects laboratory confirmed that damage threshold is experimentally equivalent for a CW and quasi-CW exposure, but the mechanisms for damage are different. Knowledge from this analysis will provide valuable insight for laser safety in battlefield situations involving the application of mode-locked femtosecond and picosecond lasers.

Background

Previous data shows that within the visible wavelength region, a pulsed laser with a repetition rate greater than 20 kHz (quasi-CW) damages the retina at the same total energy as one with the energy distributed evenly over the exposure (i.e., CW exposure). Fundamentally, femtosecond mode-locked (MHz) beams deliver energy differently than CW beams, depositing discrete packets of very high energy (peak power) followed by periods of no photon delivery (nanosecond timescale). These high peak powers do, however, average over time as overall lower total energy is delivered.

Because thermal relaxation in biological tissues requires longer time scales than that provided between pulses of a femtosecond mode-locked beam, incoming pulses deposit their energy faster than the tissue can dissipate the heat generated. This leads to heating of the tissue at rates similar to those achieved by CW laser exposure. Earlier experiments proved this to be true in live animal testing but noted differences in retinal pathology.

To test the theory in an *in vitro* setting, scientists chose the human retinal pigment epithelial cell line hTERT-RPE1, which is immortalized by the introduction of the human telomerase reverse transcriptase gene. The hTERT-RPE1 cells were proven to be highly efficient at cellular uptake (phagocytosis) of isolated melanosome particles and stably retain the pigment granules. Because melanosome-dependent laser bioeffects are known, the use of the artificial pigmentation of hTERT-RPE1 cell cultures as a defined system for analyzing the effects of pigmentation in laser-tissue interaction were proposed.

Human Effectiveness
Emerging Technologies

Additional information

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